Review of Effects of the Proposed Pebble Mine on Fish Values in the FEIS:
The Portfolio Effect

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Summary

The FEIS mispresents the magnitude of the impact that the proposed mine is likely to have on ecologically, culturally, and economically important populations of salmon in the mine area, the Nushagak River, and all of Bristol Bay. The FEIS falsely contends that the impacts of the immediate area of the mine will negligible. And, because impacted area is a relatively small proportion of Bristol Bay that the overall effect to the productivity of Bristol Bay will be negligible. The FEIS assumes that because certain habitats or streams currently produce a small number of fish (e.g., as determined from the 2-4 years of monitoring within the FEIS), that they do not have the potential to support higher abundances in the future. However, the abundance of local populations can vary by 100 fold over a decade, so populations that are have low abundance currently can high numbers in the future. The failure to acknowledge this inevitably leads to underestimating the ecological value of habitat that could be impacted by the mining activities. Based on the most recent science, salmon populations in a collection of watershed such as Bristol Bay should be viewed as a portfolio where its sustainability depends on the diversity of habitats and populations across the basin. The FEIS does not view the system in this dynamic way and, thereby, distinctly underestimates the importance of small components of habitat and populations to the long-term sustainability of the ecosystem. The North and South Fork Koktuli Rivers have populations of Sockeye salmon that have a unique genetic signature and life history. This life history is believed to be important for colonizing new habitats and eventually morphing into locally adapted populations, which maintains long-term productivity. The loss or decline of these populations could have disproportional consequences to the long-term productivity of Sockeye salmon in Bristol Bay.

Review

The FEIS concludes that: (1) The loss of habitat is not expected to have a measurable impact on fish populations based on physical habitat characteristics and fish density estimates in the affected reaches. (4.24 – 1); (2) effects of flow alterations will be minimal (4.24 – 12); and (3) "slight" temperature increases would be within required water quality standards, implying that there would not be any negative effects (4.24 -4). And, "…considering the physical characteristics and current fish use of habitat to be removed, the consequently low densities of juvenile Chinook and coho observed in the affected tributaries, and the few numbers of spawning coho observed (see Section 3.24, Fish Values), impacts to anadromous and resident fish populations from these direct habitat losses would not be measurable, and would be expected to fall within the range of natural variability."[1] (4.24 – 46). As a result, "impacts [of the operation of the mine - added] to Bristol Bay salmon are not expected to be measurable and given the vast breadth and diversity of habitat (and salmon populations) in the Bristol Bay watershed, are certain but not likely to be noticeable in context of the Bristol Bay watershed. (p. 4.24 - 47).

[1] See appendix for more detailed discussion of the range of natural variability

This conclusion is not supportable or valid for a number of reasons. First, it is only true if effects from the mine are not "measurable". A review of the analysis of the effects of the mine on fish habitat found no support for this suggestion. Rather, they are likely to be significant as a result of the direct loss of habitat and wetlands (Fennesy), altered flow and temperature regimes (Reeves, Lubetkin, Wobus), and an increase in heavy metal concentrations (O'Neal). These individual effects and their cumulative effect and the failure to consider climate change render the conclusion of no measurable effects highly questionable and most likely wrong.

The contention in the FEIS that the effect of the mine on the overall productivity of Bristol Bay will be miniscule because 0.08 percent of the total amount of habitat in the entire Bristol Bay watershed will be affected is false and misleading. Bristol Bay is a collection of populations in the different watersheds (see additional discussion later in this report) that wax and wane asynchronously through time (Fig. 1). Their collective behavior maintains the area's high and relatively stable levels of production. Thus, the appropriate scale is the watersheds that will be affected by the mine, which makes the magnitude of the potential impacts much larger.

The FEIS relies on an inappropriate assessment of fish habitat. The analysis assumes that: (1) the density or abundance of fish is constant; (2) the loss of a segment of the population or habitat will not affect the behavior of the portfolio; and (3) effects are limited to the mine site and there is no downstream transport of them. Regarding the first assumption, fish numbers in the affected streams used in the FEIS were collected from 2004 – 2008 and were deemed to generally be low (FEIS 3.24 – 29-59), even though there was recognition of a large amount of interannual variability (3.24-35). The FEIS assumes that habitat quality and its capacity to support fish is static across space and time – an assumption that has been widely discarded by aquatic ecologists for over a decade. Because an area has low productivity or abundance at one point in time does not mean that it did not support higher abundances in the past and will not support higher abundances in the future. Longer term data on Bristol Bay rivers shows that local abundances can vary 100 fold over decade-long time scales (the range of natural variability) (Davis and Schindler in review), a feature of fish populations in a pristine ecosystem (Schindler et al. 2010, Moore et al. 2010, Davis and Schindler in review). Figure 2 from Brennan et al. (2019) shows how the relative production of Chinook and Sockeye salmon within the Nushagak River varied over a 2 - 4 year period. In the Koktuli River, which will be affected by the mine, relative production ranged from low to moderately high in 2011, 2014 and 2015 for Chinook salmon and in 2014 and 2015 for Sockeye salmon, which was higher than the FEIS contends.

Properly functioning watersheds should be viewed as portfolios, where the sustainability of the regional resource depends in part on the fact the in productive ecosystems all populations do not boom and bust at the same time (ie., low abundance or production in one area of the watershed are offset by high abundance or production in other areas – the portfolio effect) (Schindler et al. 2010, Moore et al. 2010, Brennan et al. 2019). Despite repeated suggestions by the commenting agencies (EPA, USFWS, ADFG) and interested parties, the FEIS does not view the system in this dynamic way and as result mischaracterizes the consequences of the effects of the mine.

The FEIS analyses (3.24 – 1) recognizes that Sockeye salmon in the North and South Forks of the Koktuli River have a genetically unique life-history form (Dann et al. 2012; Shedd et al. 2016). However, it neglects the importance of these populations for maintaining the long-term productivity of Sockeye Salmon in Bristol Bay. And, it completely neglects to acknowledge impacts of the mine on these populations could have detrimental impacts on the productivity of the Nushagak River and Bristol Bay. Dann et al. (2012) identified these fish as a sea/river

ecotype, an anadromous form of Sockeye salmon that does not spend any part of its life in a nursery lake before migrating seaward (Wood et al. 2008), in western Alaska. This ecotype may be more genetically diverse than lake ecotypes (Beacham et al. 2004, McPhee et al. 2009) and are more similar to each other than they are to local lake ecotype populations (Wood et al. 1989; 1994). They also differ in body shapes from their lake counterparts (Pavey et al. 2010). This ecotype is limited in to the Nushagak and Togiak Rivers in Bristol Bay (Dann et al. 2012). And, the populations in the South and North Fork of the Koktuli River are genetically unique (Dann et al. 2012; Shedd et al. 2016)

The sea/river ecotype appears to be essential to the long-term persistence of the Sockeye salmon portfolio. They colonize new drainages and habitats, serving as the pioneers in establishing new populations and allowing the species to persist in temporally and spatially dynamic environments such as Bristol Bay (Wood et al. 2008; Larson et al. 2019). Life-history diversity can also increase production and buffers population fluctuations, particularly over long time periods (Greene et al. 2010). The aggregate behavior of the salmon populations in Bristol Bay increased the stability of the overall return by 41%–77% compared to individual populations (Schindler et al. 2010), in part, because of the diverse life histories within this complex (Greene et al. 2010). The loss or decrease in genetic and life-history diversity could result in the overall decline of the performance of the portfolio (Moore et al. 2010, Greene et al. 2010, Carlson and Satterwaitte 2011) and compromise its ability to respond to challenges posed by climate change and natural events such as earthquakes or tsunamis.

The direct loss of stream from the mine, about 100 miles (4.24 -8), about 12% of the riverine habitat in the Koktuli River, will have direct and indirect effects on fish in the affected streams. The most obvious is the loss of habitat. The FEIS considered this to be minor effect because of the this is a relatively small proportion of the larger Nushagak River (4.24 – 8). This argument is not supported for two reasons. First, even though some of the miles that will be loss do not support fish, they are important ecologically. They are important sources of water, food, sediment, and nutrients to downstream areas (Wipfli et al. 2007). They could also be important overwintering habitats (Hance et al. 2016). Disruption of this connection can dramatically impact downstream riverine ecosystems (Wipfli et al. 2007), which support this genetically unique life-history.

In summary, the portfolio theory is an important and unifying concept in salmon biology and conservation. The contention is that the loss of a small number of assets (i.e., populations in the area directly impacted by the mine) within the portfolio will not affect overall portfolio performance because other assets will presumably remain productive (4.24 – 46-47). But, there is no guarantee that the productivity of other assets will be maintained or improved because a component of the portfolio is lost; we shouldn't expect the other populations to have continuous high and stable productivity over time. This has a solid theoretical and empirical bases, as diminished (i.e., less diverse) portfolios are known to be less stable and less productive (Greene et al. 2010). Therefore, it is very risky to assume that the loss of production from one population will be offset by improved production from other populations. It is actually more likely that mine effects resulting in the loss of salmon production could cause a measurable decrease in the overall performance of the Bristol Bay portfolio.

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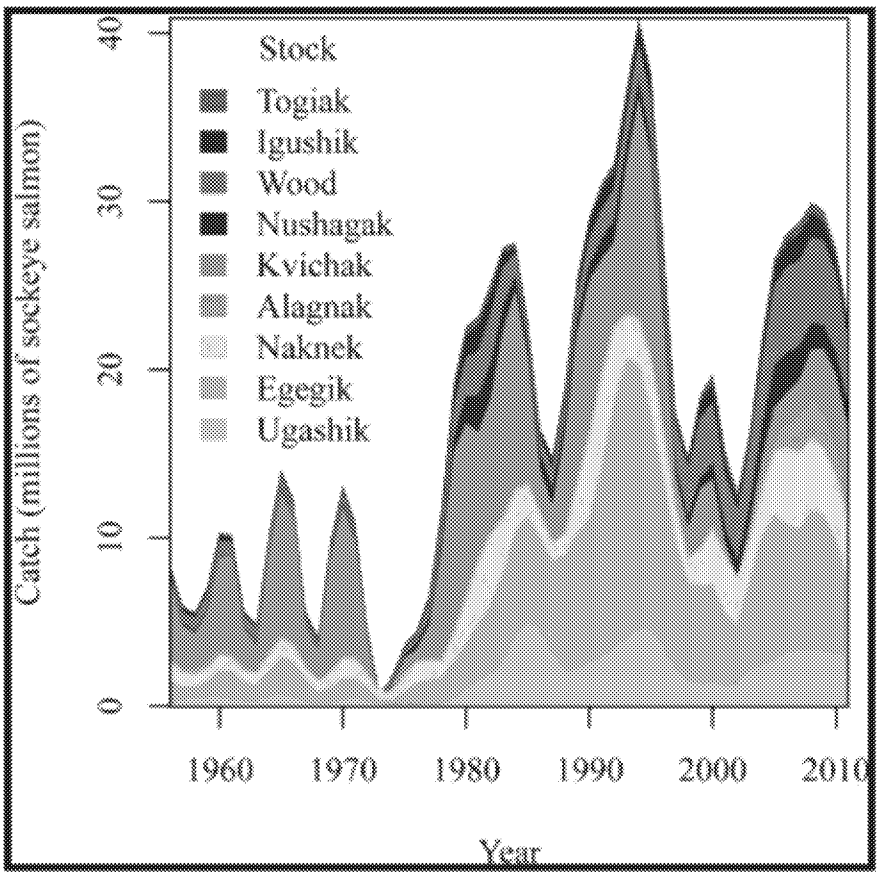

Figure 1. Contribution of different populations of Sockeye Salmon to the commercial fishery over time. The "stocks" (populations) affected by the proposed Pebble Mine are the Nushagak and Kvichak. (from: Dann et al. 2013)

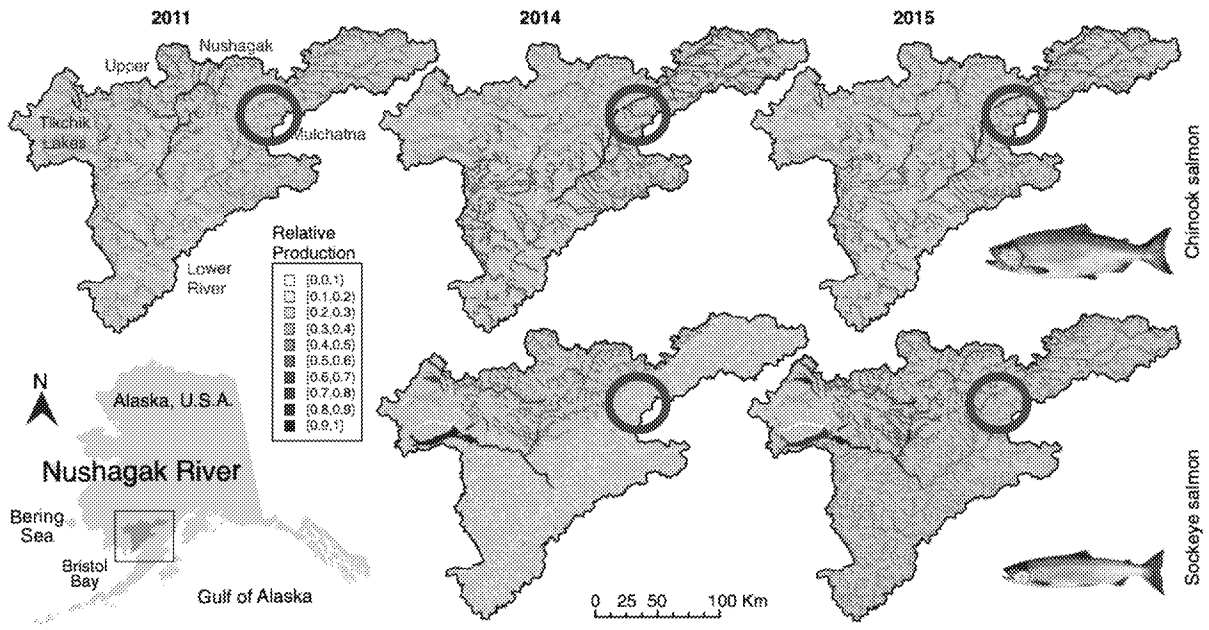

Fig. 1. Productive habitats for salmon shift across river basins. Areas of high Chinook salmon production in 2011 shifted from the upper Nushagak River to the Mulchatna River in 2014 and 2015. Sockeye salmon production was concentrated in Tikchik lakes in 2014 but was more evenly distributed in 2015 including across riverine habitats.

Figure 2. Relative production of Chinook and Sockeye Salmon in the Nushagak River in 2014 and 2015 (from: Brennan et al. 2019). Blue circles indicate the approximate location of the proposed Pebble Mine.

Appendix

Range of Natural Variability

The FEIS contends that even with the direct loss of habitat in the affected streams that the populations should continue to maintained within the "range of natural variability" (p. 42.4-46). This is the first mention of the range of natural variability and the suggestion that effects from the mine will not affect it. This is not a supportable contention and, thus, underestimates the potential effects of the mine.

The range of natural variability is not a single value or range of values, rather it varies inversely with the level of biological organization or spatial scale (the smaller the scale or level of organization the larger the variability) (Wimberly et al. 2000). Davis and Schindler (in review) show that individual populations of Sockeye Salmon exhibit large swings in from very low to high over time (the range of natural variability). The extent of the higher population levels depends to a large degree on the amount and quality of habitat. A decrease in available habitat would necessarily reduce the range of natural variability of the affected local population. And because areas of production vary through time (see discussion on page 2 of this document), the performance of the portfolio of populations in the Nushagak River, which is responsible for the long term sustain productivity of salmon in the affected watersheds and Bristol Bay, could be affected.